

STABILIZATION MEASURES – ROCK FALL PROTECTION

Lesson 8 – Topic D

LESSON 8D - ROCK FALL PROTECTION MEASURES

Learning Outcomes -

- ***Identify the engineering parameters required to design rock fall protection measures;***
- ***List the various methods for rock fall protection;***
- ***Identify design tools for rock fall protection methods such as ditches and fences;***
- ***Discuss the drawbacks and merits of benches on slopes.***

Protection Measures Against Rock Falls

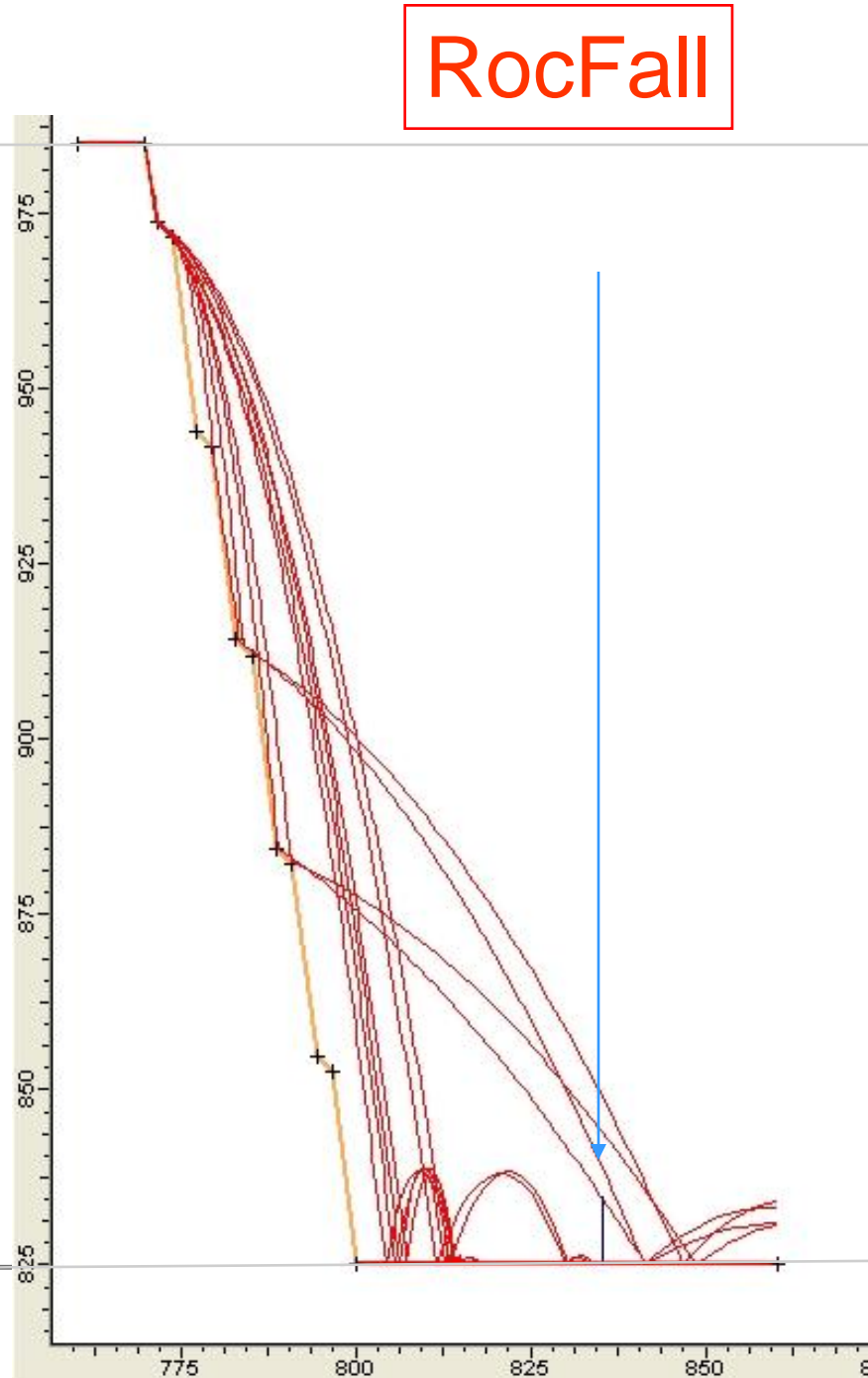
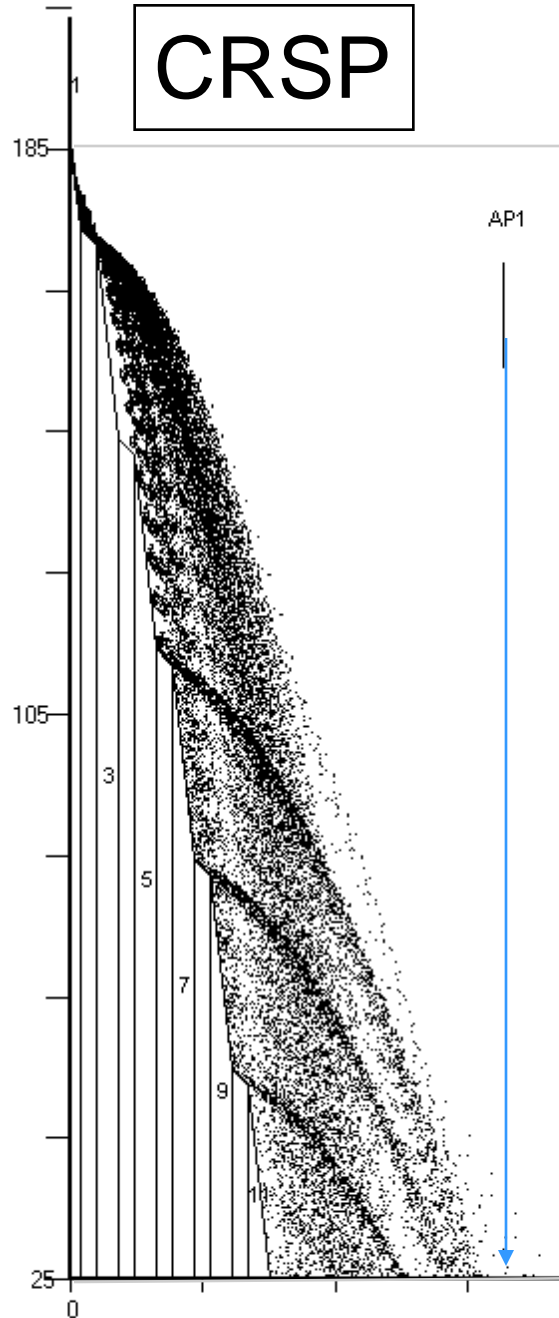
- ***Rock Fall Modeling***
- ***Uniform Slopes Preferred to Benched Slopes***
- ***Ditches - Ritchie Ditch Design Chart***
- ***Barriers - Gabions, Concrete Blocks, Fabric/Soil Structures***
- ***Rock Catch Fences, Energy Attenuators***
- ***Draped Mesh***
- ***Warning Fences, Sheds, Tunnels.***

ROCK FALL MODELING

Simulation Programs -

- ***Multi variable problem;***
- ***Site calibration;***
- ***Collateral information;***
- ***Colorado Rockfall Simulation Program (CRSP);***
- ***RockFall (RocScience).***

Stage 1 Rock Fall Analyses

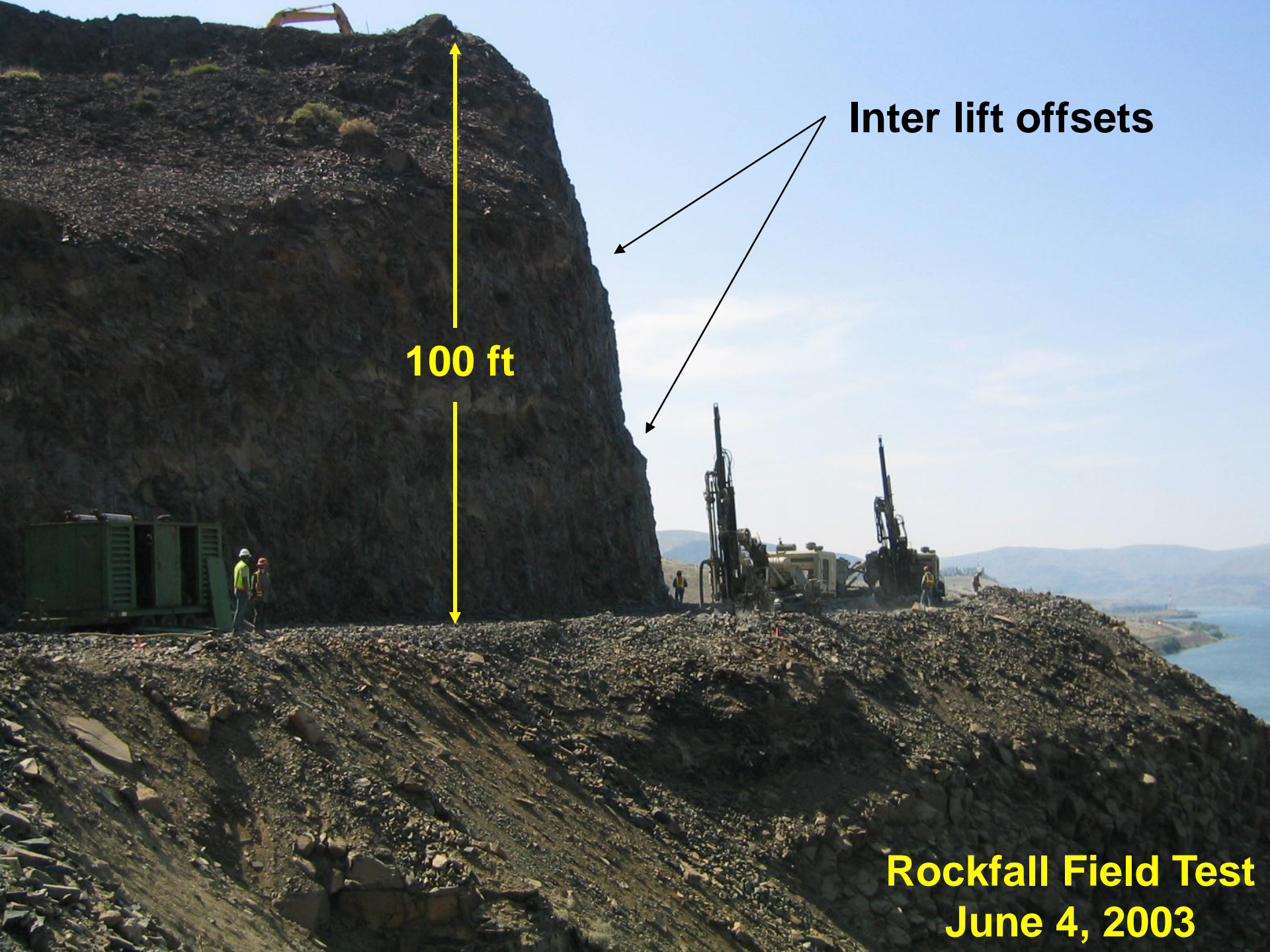


Collateral Rockfall Evidence



Collateral Rockfall Evidence





100 ft

Inter lift offsets

**Rockfall Field Test
June 4, 2003**

Proposed Fence Location @ 35 ft



**Percentage of rocks striking fence
“on the fly”:**

@ 35 ft = 0%

@ 30 ft = 8%

@ 25 ft = 20%

Benches on Rock Slopes





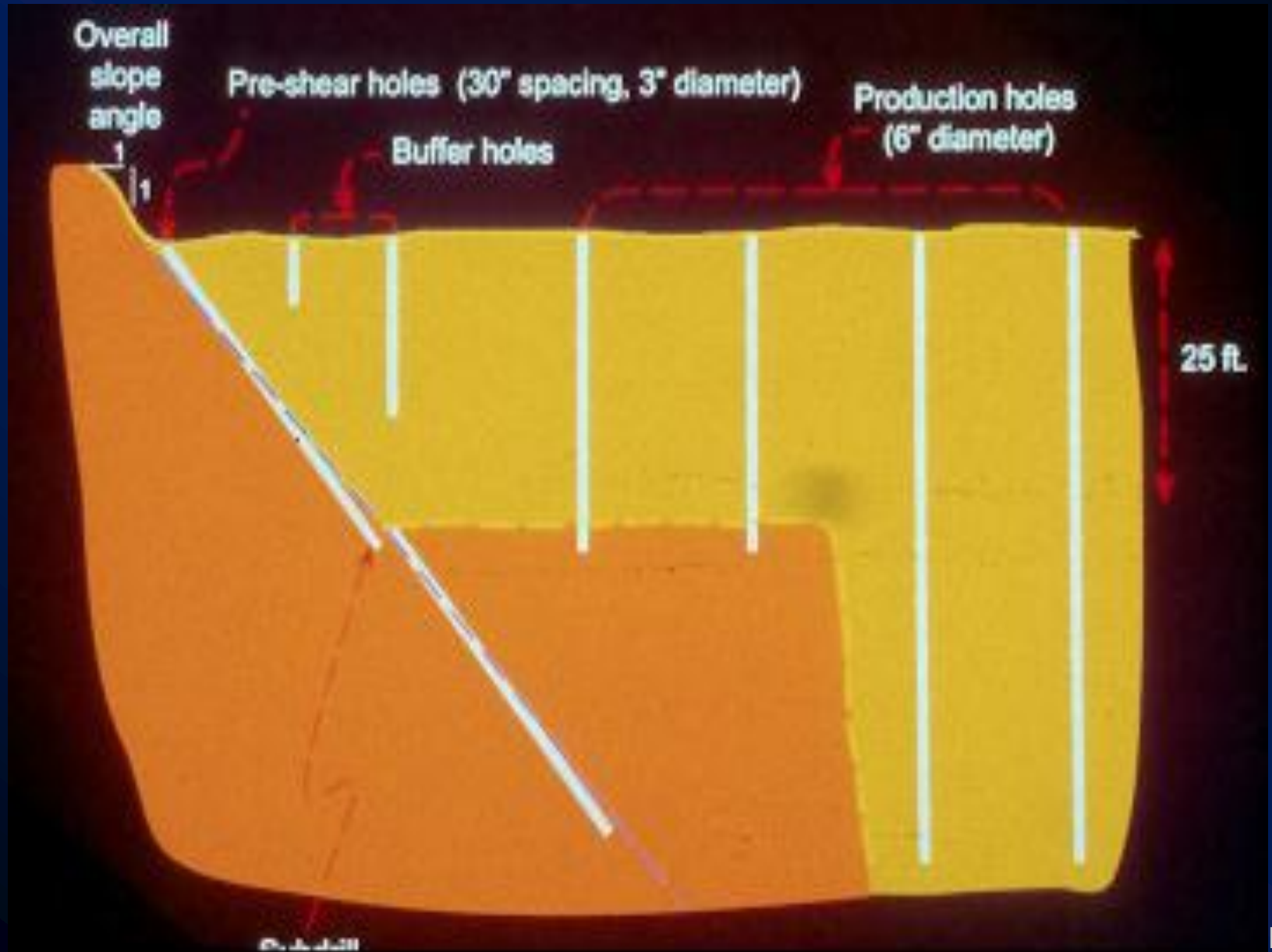








Controlled Blasting – Blast Hole Layout







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Rock Fall Protection Measures

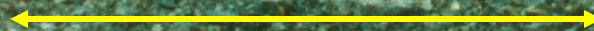
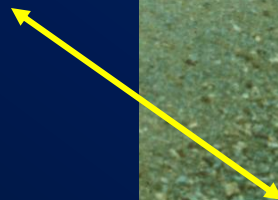
**Catchment Area
a.k.a. “Ditches”**



**PATH OF ROCK TRAJECTORY
ON VARIOUS SLOPES**

Trapezoidal Ditch (1984 design)

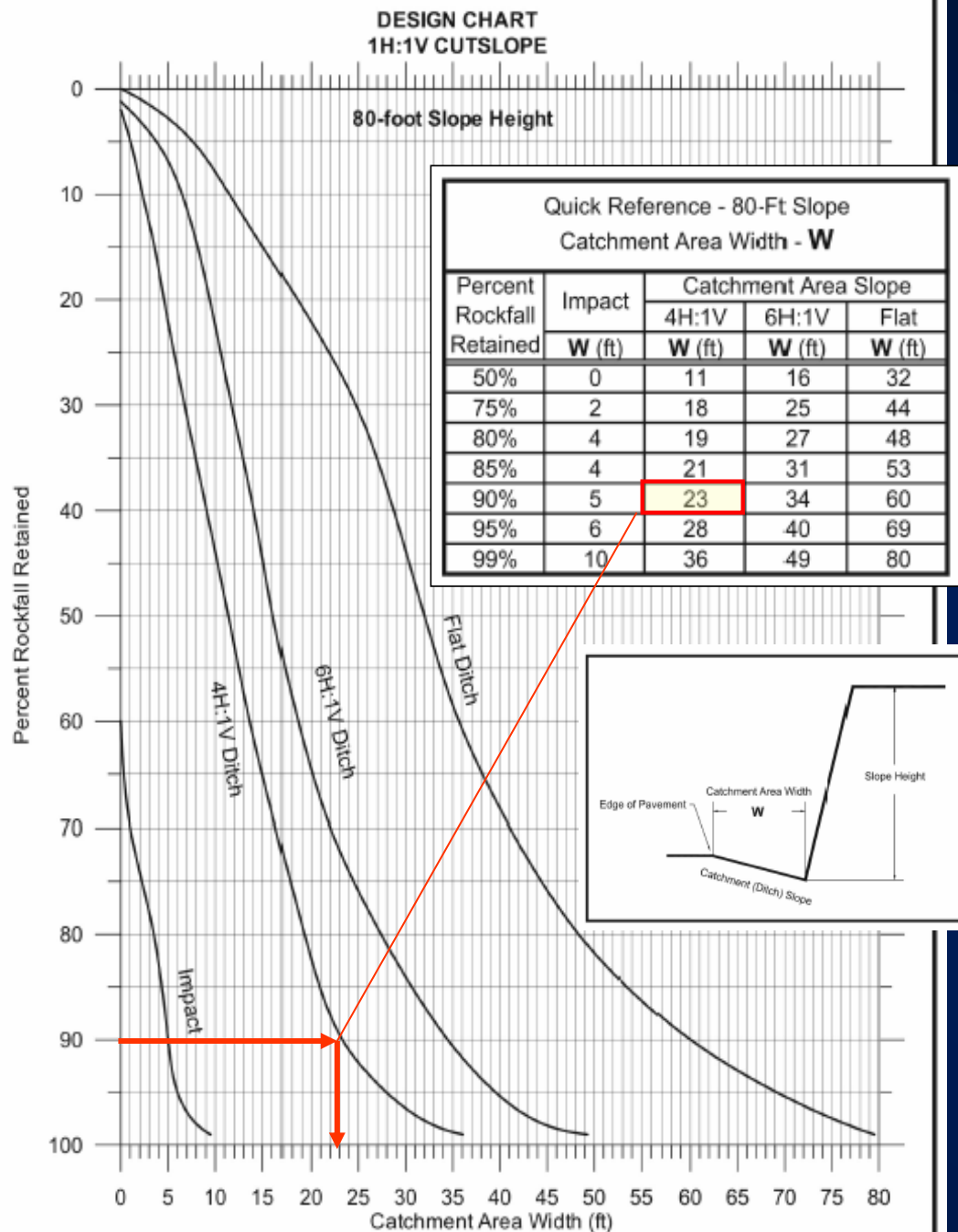
Steep Slope



Flat Bottom



ODOT Design Guide (2001)



“Recovery Zone”

Ditch Enhancement: Gabion Baskets



A photograph of a pet rock prison. The prison is constructed from a large number of smooth, rounded stones of various shades of grey, blue, and tan, piled together to form a rectangular enclosure. A small, dark, rectangular sign with white text is placed on top of the stone wall. The sign reads "PET ROCK PRISON". The background is a light-colored, sandy or silty surface. The overall image has a slightly grainy, vintage quality.

PET ROCK
PRISON

4 8'9 1

Ditch Enhancement: Fence



Ditch Enhancement: Interlocking Concrete Blocks





Ditch Enhancement: Concrete with Sacrificial Facing



Ditch Enhancement: Gabion Baskets



Ditch Enhancement: Recycled Tires



Rock Fall Protection Measures

■ ***Slope Drape***

- ***Mesh***
- ***Cable Net***

Slope Drape - Mesh



Slope Drape - Mesh

Twisted Wire Mesh

or

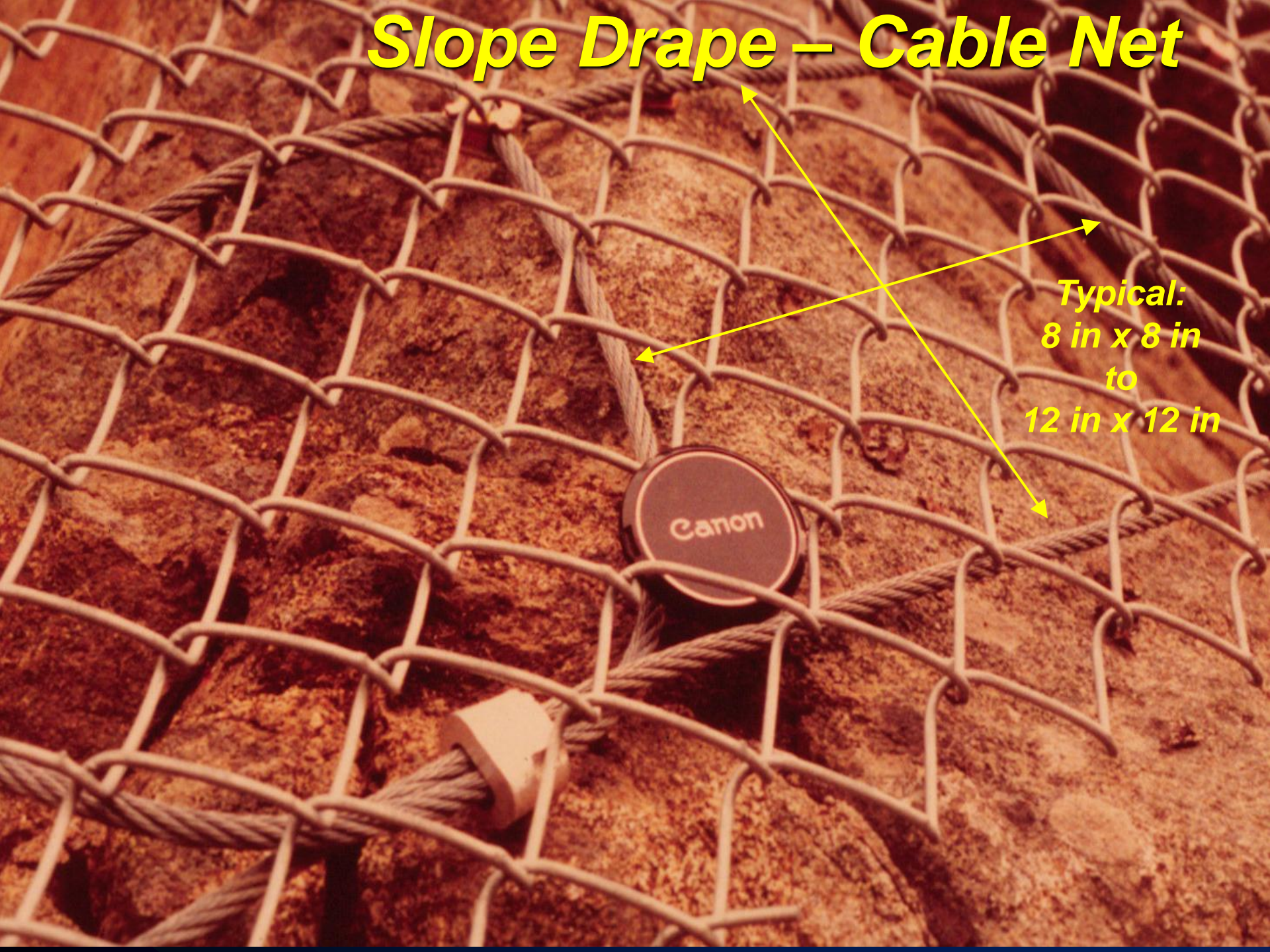
Chain Link



Slope Drape Aesthetic Treatment



Slope Drape – Cable Net



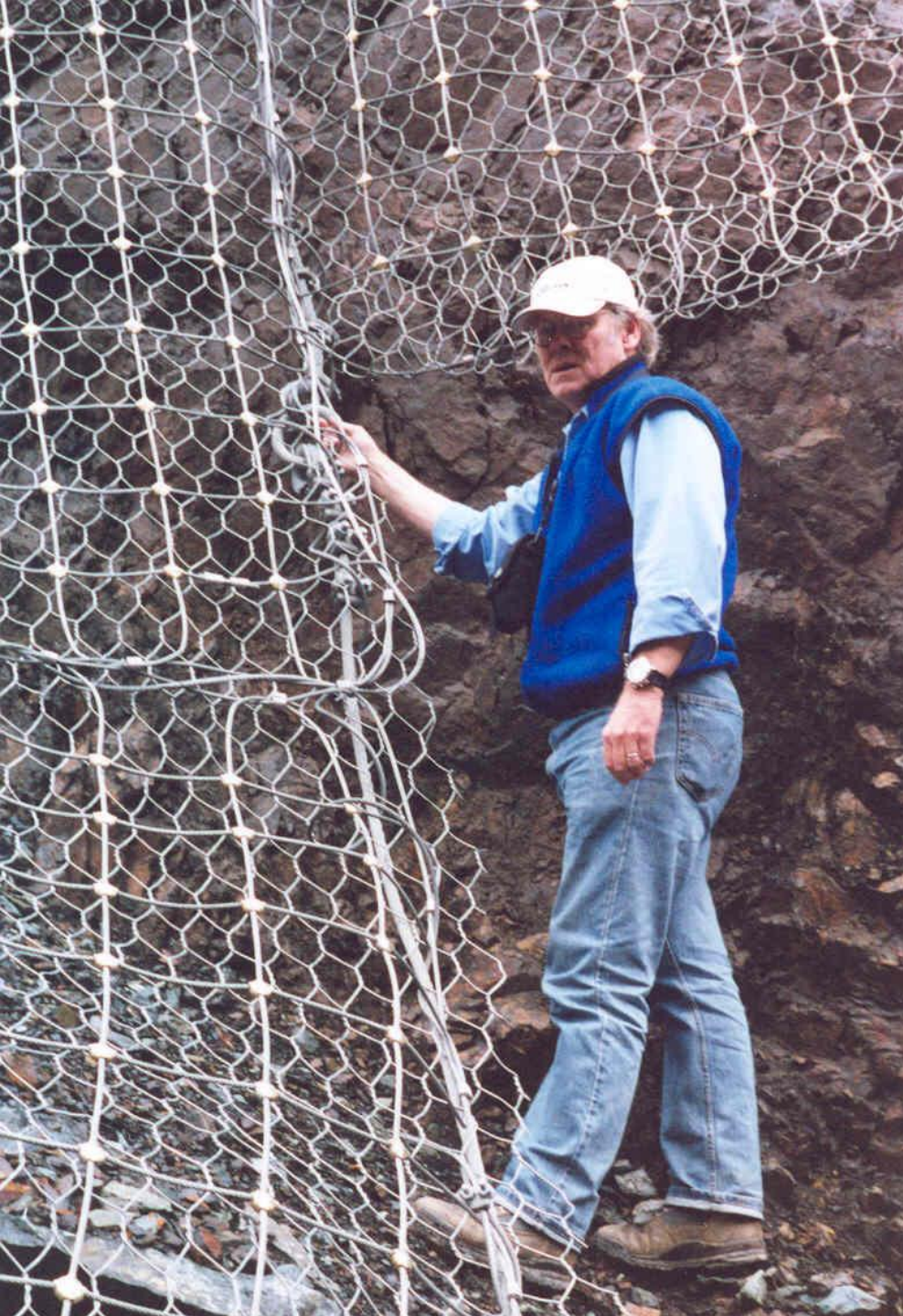
***Typical:
8 in x 8 in
to
12 in x 12 in***

Canon

Slope Drape Installation



Slope Drape – Cable Net



Slope Drape Mesh Failure



Slope Drape Mesh Failure



Modified Slope Drape





Typical Slope Drape Design Issues

Variables:

- **Block Size**
- **Slope height / inclination**
- **Interface friction**
- **Impact loads**
- **Snow / ice loads**

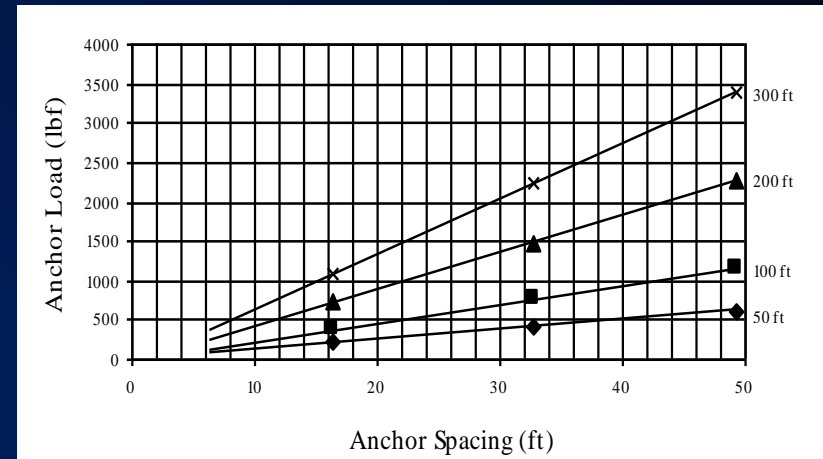


Table 1. Recommended maximum anchor spacing as a function of slope height

Slope Height <i>m</i> (ft)	Anchor Spacing ^{1,2} <i>m</i> (ft)
≤ 30 m (100 ft)	15 m (50 ft)
30 – 60 m (100 – 200 ft)	10 m (35 ft)
60 – 90 m (200 – 300 ft)	5 m (20 ft)

REF: Muhunthan, B., S. Shu, N. Sasiharan, O.A. Hattamleh, T.C. Badger, S.M. Lowell, and J.D. Duffy, 2005b. Design Guidelines for Wire Mesh/Cable Net Slope Protection, Washington State Transportation Center (TRAC) Report No. WA-RD 612.2, Seattle, Washington, 60 p.

Rock Fall Protection Measures

- Fences***





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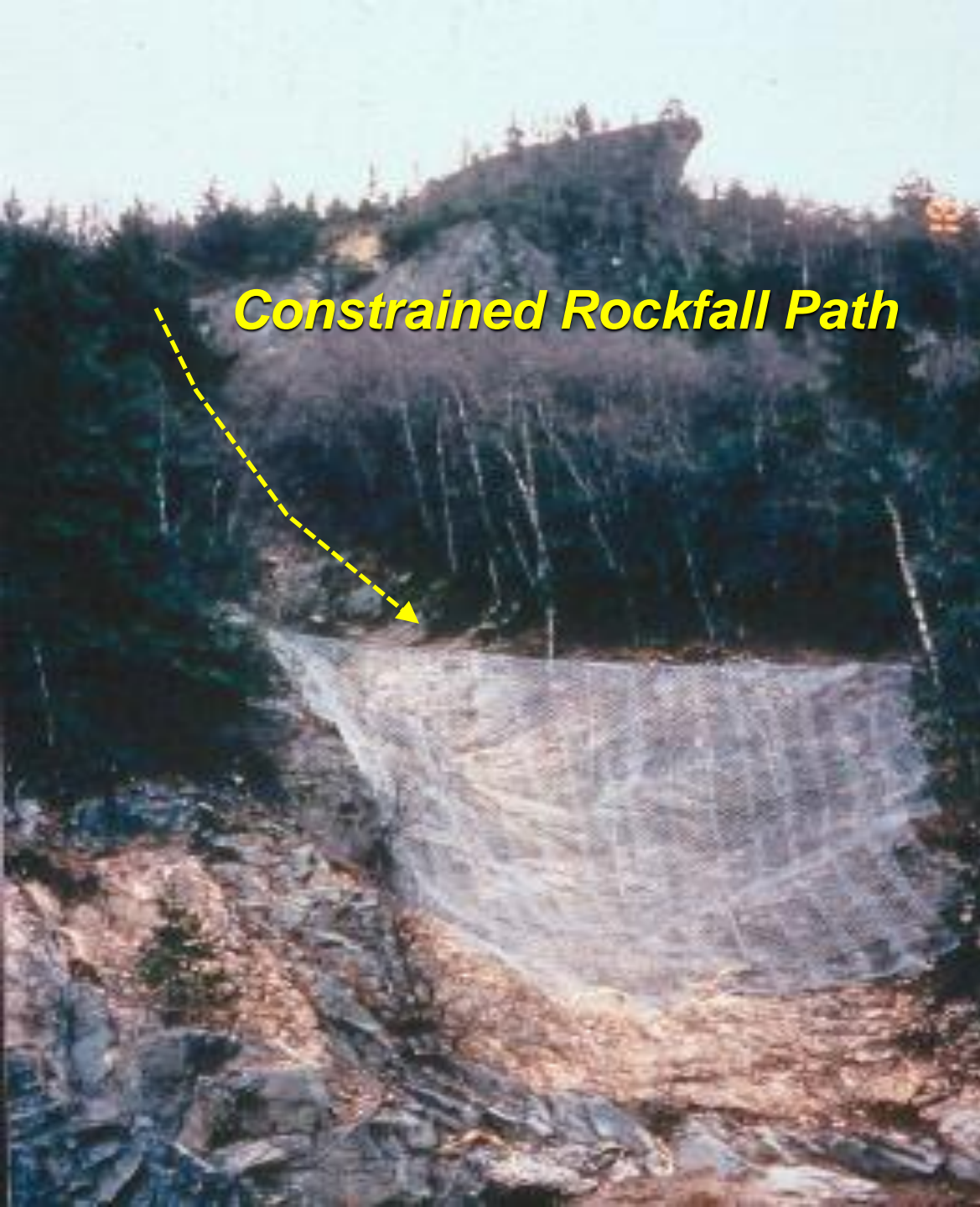
“Brute Force” Fence

TRIANGLE ROCK/SNOW FENCE

Japanese Fence Technology

03710/192221

Suspended Nets



Constrained Rockfall Path



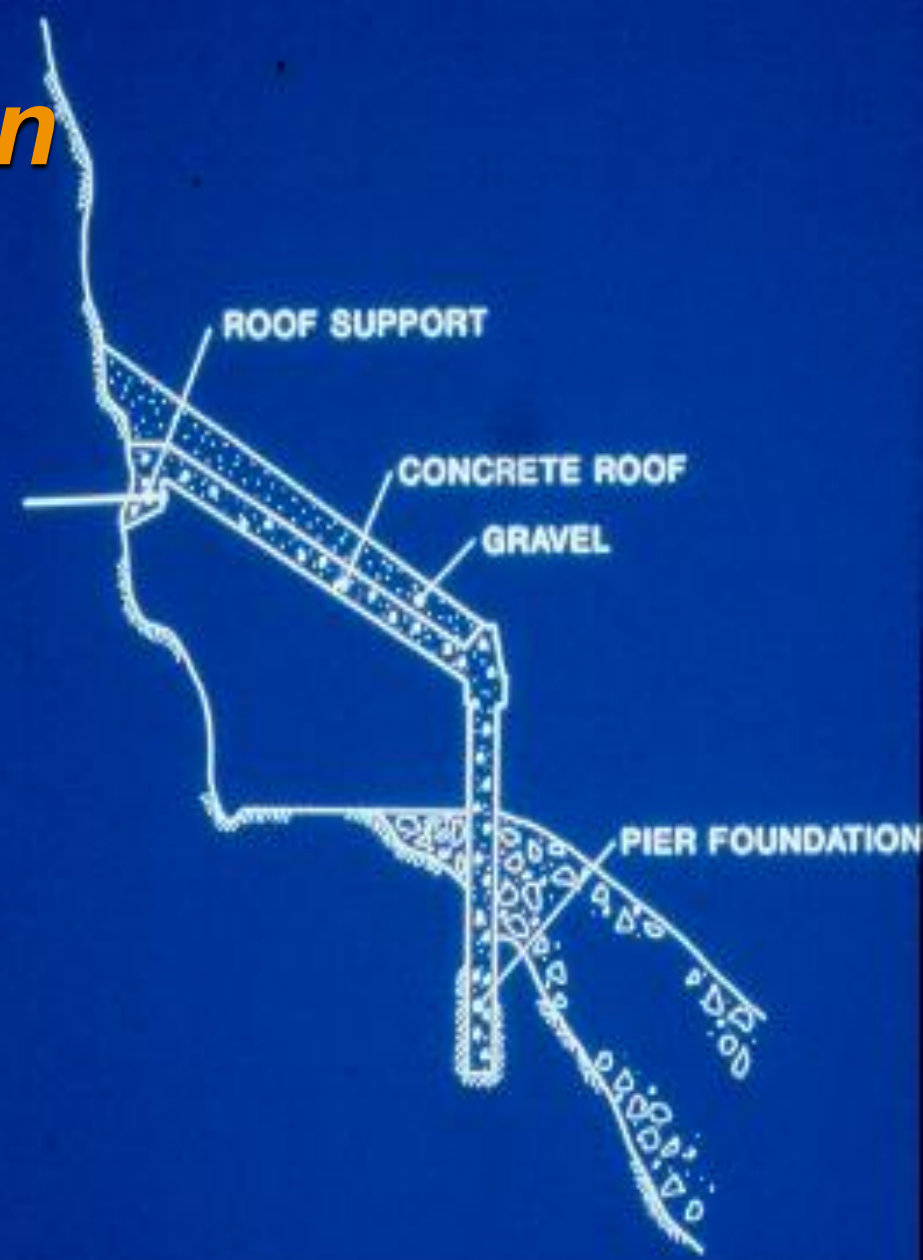


Hybrid Barrier and Fence



Rock Fall Protection Measures

■ Sheds



ROCK SHED

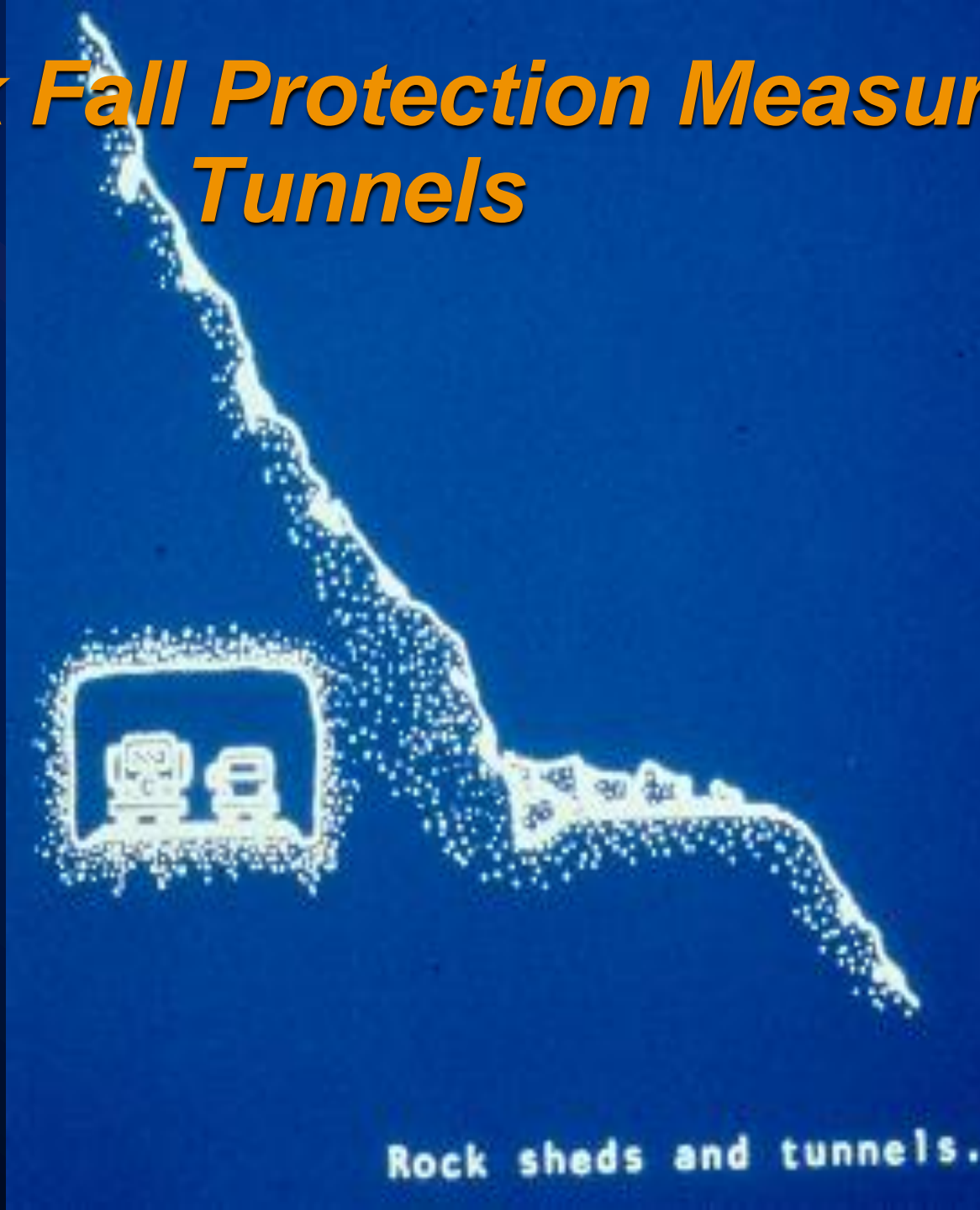






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Rock Fall Protection Measures: Tunnels



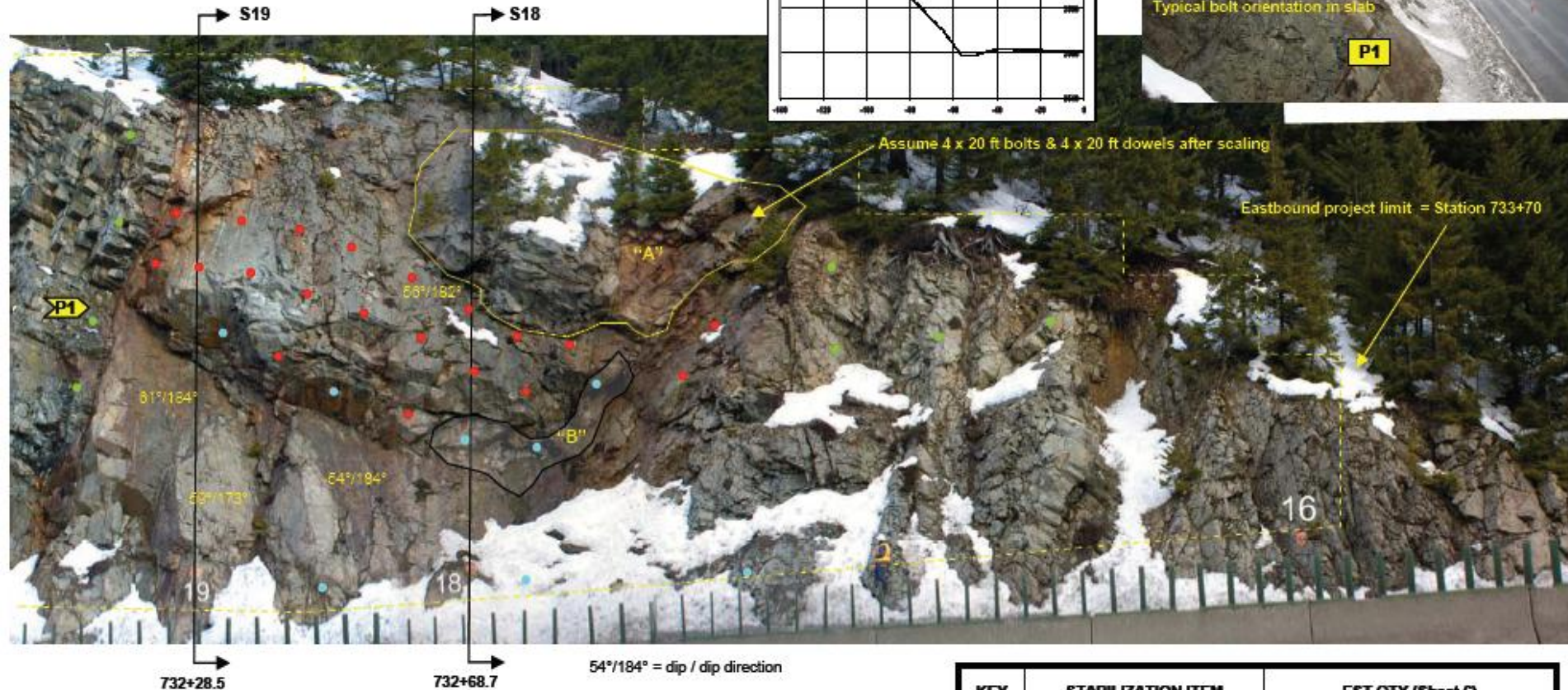
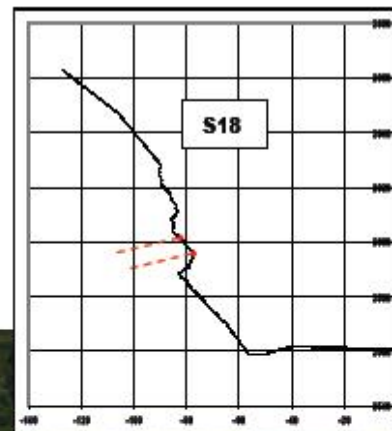
Rock sheds and tunnels.



Rock Fall Protection Measures: Warning Systems



SHEET No 6: Middle Cut **I 90 MP 66.27 – 66.31 (Left) WB**



Stabilization Sequence:

- ▶ Remove rock slab at location "A" using mechanical scaling.
- ▶ Intensive hand scaling with selective mechanical scaling of entire slope including tree removal from face and 15 ft beyond crest to clearing limit.
- ▶ Install rock bolts or dowels from **top down** at specified locations and as directed by the Engineer.
- ▶ Apply 4-inch minimum thickness fiber reinforced shotcrete at location "B".
- ▶ Install horizontal drains at locations shown (upper row = 5 @ 30 ft, lower row = 3 @ 40 ft)
- ▶ Install 12" x 12" cable net with double-twist wire mesh to limits shown (12 ft +/- 2 ft above ditch).

KEY	STABILIZATION ITEM	EST QTY (Sheet 6)
●	60 kip tensioned rock bolt	24 x 20 ft = 480 ft
●	60 kip untensioned rock dowel	12 x 20 ft = 240 ft
●	Horizontal drain	3 x 40 ft + 5 x 30 ft = 270 ft
	Scaling / Debris removal	40 crew hr & 2 machine day / 2000 cy
	Shotcrete	40 ft x 10 ft x 4 in = 5 cy
---	Slope Drape	140 ft x 70 ft avg = 9800 sf





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